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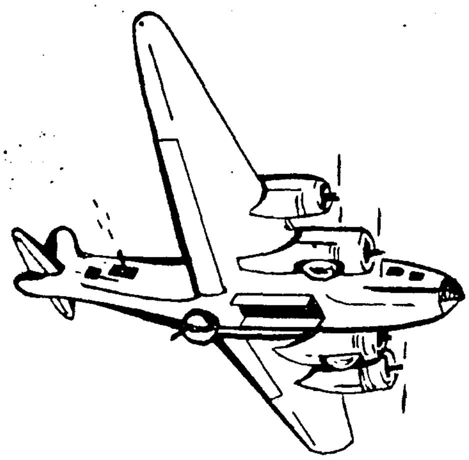

MEMORANDUM
REPORT No. 531

Vulnerability of B-47B Wing to Internal Blast

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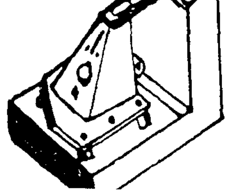

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AMSRL-MO-IS (380a) 1 February 1996

MEMORANDUM FOR Defense Technical Information Center, 8725 John J. Kingman Road Suite 0944, Fort Belvoir, VA 22060-6218

SUBJECT: BRL Memorandum Report No. 531

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Chief, Security/CI Section
ARL, APG

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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 531

March 1951

VULNERABILITY OF B-47B WING TO INTERNAL BLAST

W. E. Baker
O. T. Johnson

Project No. TB3-0238A of the Research and Development Division, Ordnance Corps

ABERDEEN PROVING GROUND, MARYLAND

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BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 531

WEBaker/OTJohnson/jld
Aberdeen Proving Ground, Md.
8 March 1951

VULNERABILITY OF B-47B WING TO INTERNAL BLAST

ABSTRACT

Some internal blast tests have been conducted on a B-47B wing. In this report are given the test findings and the predictions for 100A, 50A, and 0A damage for the entire wing.

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INTRODUCTION

As a part of the overall study of weapons effectiveness, internal blast tests against various semi-monocoque[1] and more nearly monocoque[2] type aircraft have been carried out and are reported[3] in several BRL reports and memorandum reports. The results of these tests indicate that the aircraft of nearly full monocoque type construction are much more vulnerable to internal blast than those of semi-monocoque type construction.

The B-47B is a six-jet swept-wing medium bomber. Its wing consists of a strong box spar to which very light leading and trailing edges are attached. The box spar forms a nearly monocoque structure, i.e., most of its strength is in the very thick skin and spar webs. This type of construction is quite different from that of the B-17 or B-29 wings, both of which are so constructed that most of their strength lies in heavy stringers, spar caps, and ribs rather than in the skin. Typical cross-sections of a B-47 wing and a B-17 wing are shown below.

These tests continue the studies of internal blast vulnerability of nearly full monocoque aircraft structures. Rough estimates of the vulnerability of a B-47B wing to internal blast, based on firings against other aircraft, reported by Morgan G. Smith in BRL Report No. 733, "Passive Defense of Aircraft," August 1950, will have to be modified, based on the results of the actual firing tests reported herein.

EXPERIMENTAL PROCEDURES

The firings were conducted at Wichita Municipal Airport on a complete B-47B wing assembly minus the leading edge. Boeing Aircraft Company personnel and Captain R. P. Flanagan, U. S. Air Force, assisted by the making of arrangements and in the conduct of the tests. There was some pre-test damage which was the result of the wing being dropped during fabrication processes, weakening the left wing tip and the wing root section.

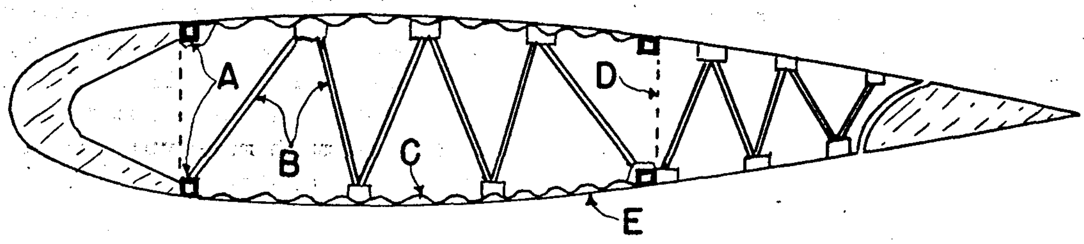
---

1. A-25, A-20, B-17, and B-29 aircraft.

2. Douglas D-558, B-36.

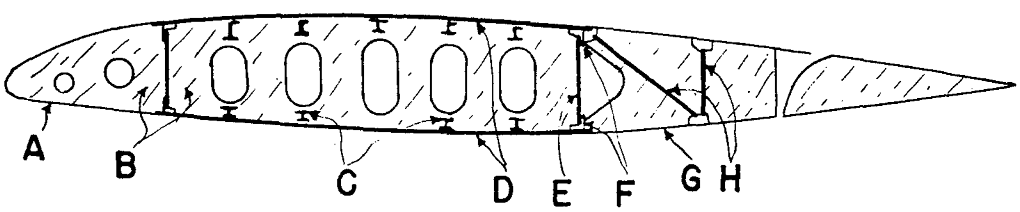
3. BRL Memorandum Report No. 436, "Report on Tests of the Effect of Blast from Bare and Cased Charges on Aircraft," James N. Sarmousakis, July 1946. BRL Report No. 645, "The Effect of Blast on Aircraft," Joseph Sperrazza and James N. Sarmousakis, August 1947. BRL Memorandum Report No. 490, "Vulnerability of B-29 Aircraft to Internal Blast," Joseph Sperrazza, June 1949. BRL Memorandum Report No. 520, "Vulnerability of Douglas D-558 Skystreak to Internal Blast," Joseph Sperrazza and Elaine Gilinson, September 1950.

TYPICAL B-17 WING CHORDWISE SECTION



- **A** Heavy spar caps
- **B** Heavy rib trusses
- **C** Inner corrugated skin
- **D** Heavy web truss running spanwise
- **E** Light outer skin

TYPICAL B-47 WING CHORDWISE SECTION



- **A** Light skin
- **B** Light rib panel
- **C** Stiffeners
- **D** Very heavy skin
- **E** Heavy plate spar web
- **F** Comparatively light spar caps
- **G** Light skin
- **H** Light bracing

The B-47B wing was supported on wooden cradles, and bare TNT or pentolite charges of the desired weight were placed at specified positions (See Figure 1). After each charge was detonated an assessor wrote a detailed description of the damage caused to the wing structure, and then estimated the probability that the damage fell in four categories designated by the letters A, B, C, and E.

A: damage resulting in aircraft beginning to fall within five minutes.

B: damage resulting in aircraft beginning to fall within two hours.

C: damage resulting in aircraft being unable to complete its mission.

E: damage resulting in crash on landing.

If the assessor thought that the damage would result in immediate loss of control the symbol K (meaning kill) was used in the A category.

The Aberdeen Proving Ground assessor was Capt. E. B. McClintick, U. S. Air Force. Structural engineers from the Boeing Seattle plant were on hand to aid the Aberdeen Proving Ground assessor in determining the extent of damage.

It was assumed that the aircraft was in level flight at normal cruising speed of about 450 mph.

A total of eight firings were made. The number of firings was limited since only one wing structure was available for the test. With the exception of the two and three pound TNT blocks all the charges were bare pentolite spheres, (1/4 lb., 1/2 lb., and 1 lb.) centrally initiated. This shape was used in order to obtain spherical shock wave distribution. The two and three pound TNT blocks were used because no spherical charges of that weight were available at the time.

Complete description and photographs of the damage from each individual charge will be found in special APG Firing Records dated 17 October 1950.

RESULTS

The results of individual firings are given in Table I. Firing positions are numbered in Figure 1.

The wing was divided into four sections chordwise; leading edge, spar box, structure aft of spar box and forward of flap and aileron hinge line, structure aft of flap and aileron hinge line. As can be seen from the airfoil cross-section in the introduction, marked differences in construction dictated this choice of sectioning. For convenience in estimating extent of damage from a single charge, each section was further divided into four spanwise parts. Final subdivision of wing area is shown in Figure 1.

By some interpolation and considerable extrapolation from the results of Table I, weights of explosive necessary to just produce 100A and 50A damage in various portions of the wing were estimated. Also, appraisals were made of the "threshold" charge weight for 0A damage, i.e., that charge weight which just fails to produce appreciable A damage. Table II gives these estimates.

In preparing Table II, several assumptions were made of the amount of damage the wing could sustain before the aircraft would fall out of control. For charges outside the spar box, it was assumed that loss of a portion of leading or trailing edge with no accompanying damage to the spar box would be considered as 0A structural damage. Similarly, loss of a wing tip outboard of the outboard engine was assumed insufficient to cause the aircraft to fall out of control and was called 0A.

TABLE I

Damage Assessments and Charge Weights for Individual Firings within B-47 Wing

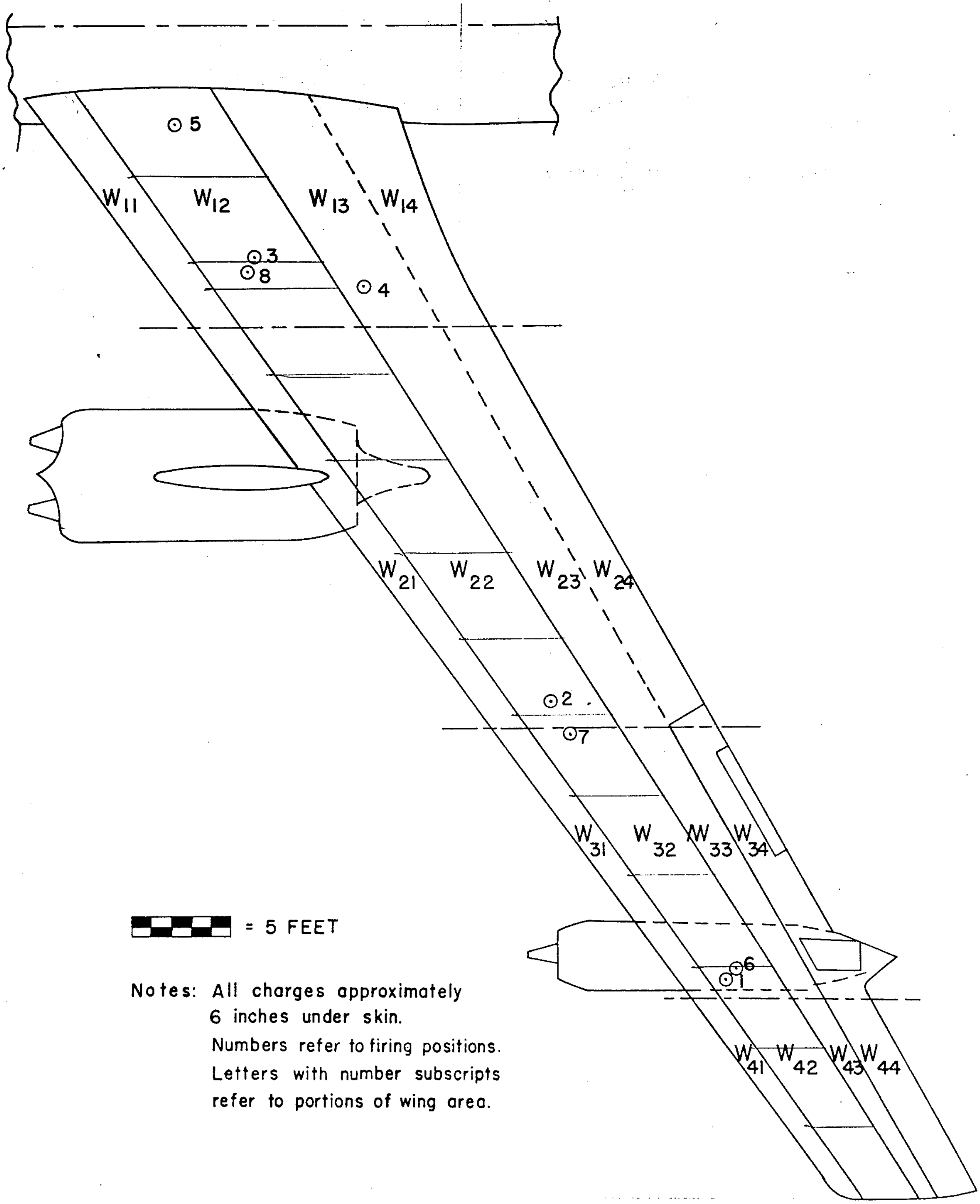
Firing No.	Charge Wt., Lbs.	Damage Assessment A	B	C	E
1*	1/4	100	100	100	100
2	1/4	0	0	0	0
3	1/2	0	0	0	0
4	3**	25	70	0	0
5	2**	K	100	100	--
6	1/4	5	10	0	0
7	1/2	K	100	100	--
8	1	K	100	100	--

* Damage here was compounded by damage sustained in fall of aircraft wing in factory.

** These charges were block TNT; all others were spherical pentolite.

FIGURE I

B-47B WING PLAN SHOWING WING AREAS OF TABLE II AND LOCATIONS OF ALL CHARGES FIRED



Notes: All charges approximately 6 inches under skin.
Numbers refer to firing positions.
Letters with number subscripts refer to portions of wing area.

TABLE II

Estimated Charge Weights (Pounds) for "A" Structural Damage to B-47B Wing

Area *	100A	50A	0A
W_{11}	3	2	1-1/2
W_{21}	3	2	1-1/2
W_{31}	2-1/2	1-1/2	1
W_{41}	3	2	1-1/2
W_{12}	3/4	3/4	1/2
W_{22}	1/2	1/2	1/4
W_{32}	3/8	3/8	1/4
W_{42}	1/2	1/2	1/4
W_{13}	4	3	2
W_{23}	4	3	2
W_{33}	3	2	1
W_{43}	4	3	2
W_{14}	8	4	2
W_{24}	8	4	2
W_{34}	4	2	1
W_{44}	5	4	1

* Areas are shown on Figure 1.

DISCUSSION

Since all but one of the test charges were fired within the spar box, the estimates of vulnerability for that section are probably more accurate than the estimates for charges outside of the spar box. From the results of test charge No. 4, it is apparent that a charge outside of the spar box must be much larger than one within the box to damage the spar box enough to cause appreciable "A" damage.

In the light of these tests, the rough vulnerability estimates given in BRL 733 must be modified as shown in Table II.

Damage occurring from charges within the spar box was of the "all-or-nothing" variety. That is, a given weight of charge produced essentially no damage, while a slightly larger charge completely wrecked the spar box for a twenty foot length. Figures 2 and 3 show the left wing spar box after firing a 1/4 lb. pentolite charge. It can be seen that the only damage from this charge was carrying away of several very light internal spar box ribs. Yet a 1/2 lb. charge in the same portion of the right spar box completely wrecked the spar box. Figures 4, 5, and 6 show the damage from this charge. As a result of this sharp demarcation in amount of charge to do crippling damage, it was assumed that any charge within the spar box large enough to do 50A damage would also do 100A damage: i.e., there is no 50A vulnerable area in the spar box.

The nature of spar box damage may be due to the material of which it is constructed (75ST aluminum alloy). This alloy has a quite high elastic limit compared to such an alloy as 24ST, but it is more brittle and hence propagates fractures much more readily than the more ductile 24ST. So, a blast which would cause only localized damage in a structure made of 24ST might cause quite general damage in a similar equal strength structure of 75ST.

It is believed that the very light construction of the ribs within the spar box minimized the damage. They merely carried away without damaging the structure to which they were attached, thus effectively reducing the confinement of the blast. Figure 7 shows this type of internal damage resulting from a 1/2 lb. charge. It is thought that a suggestion by Captain McClintick, that it may be possible to further reduce vulnerability by installing a number of very light "explosion relief" panels in the spar box outer skin, has merit.

W. E. Baker

W. E. Baker

O. T. Johnson

O. T. Johnson

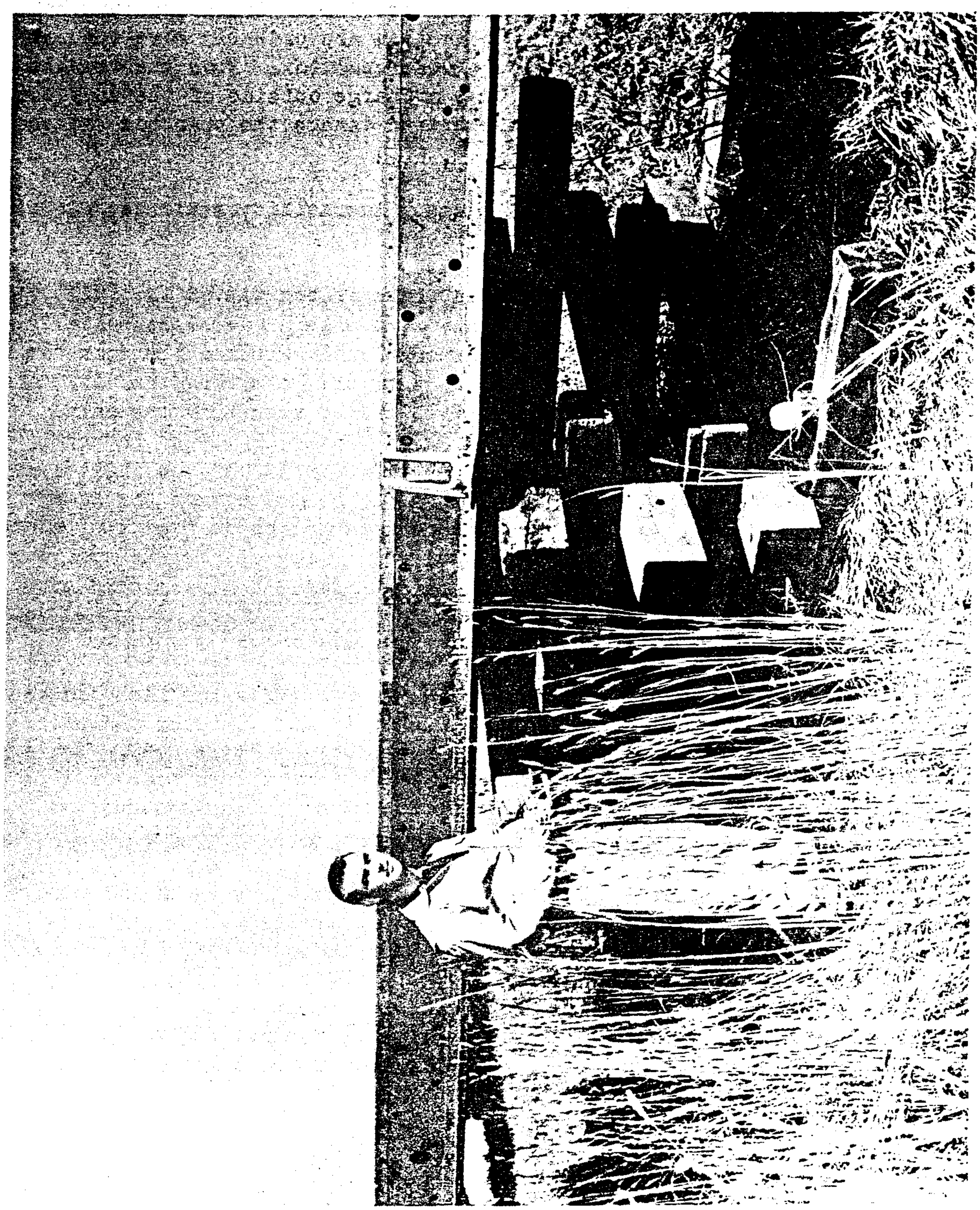


Figure 2. External View of Left Wing After Detonation of 1/4 lb. Spherical Pentolite Charge Within Spar Box.

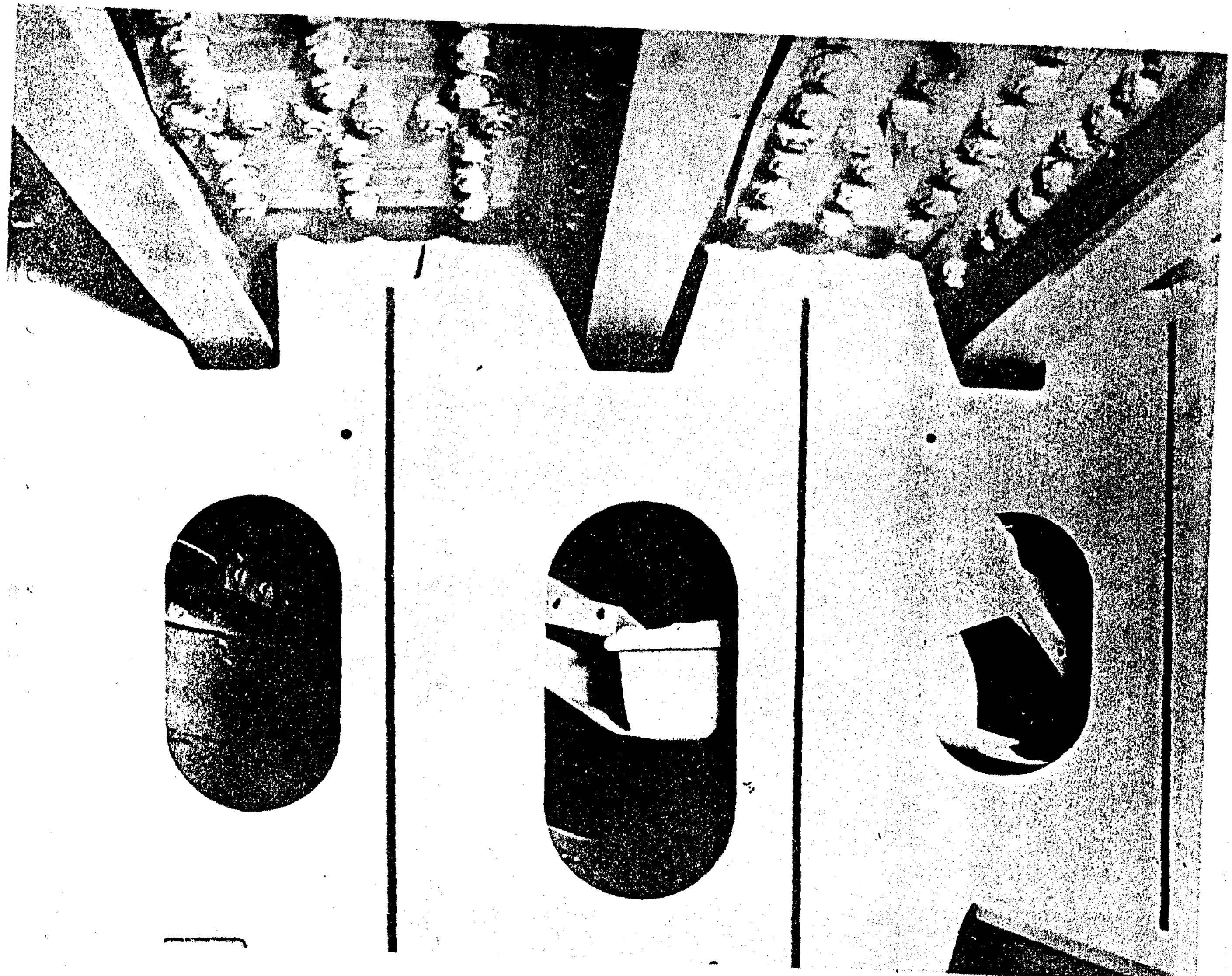


Figure 3. Internal View of Damage to Left Wing Spar Box after the Detonation of a 1/4 lb. Spherical Pentolite Charge.

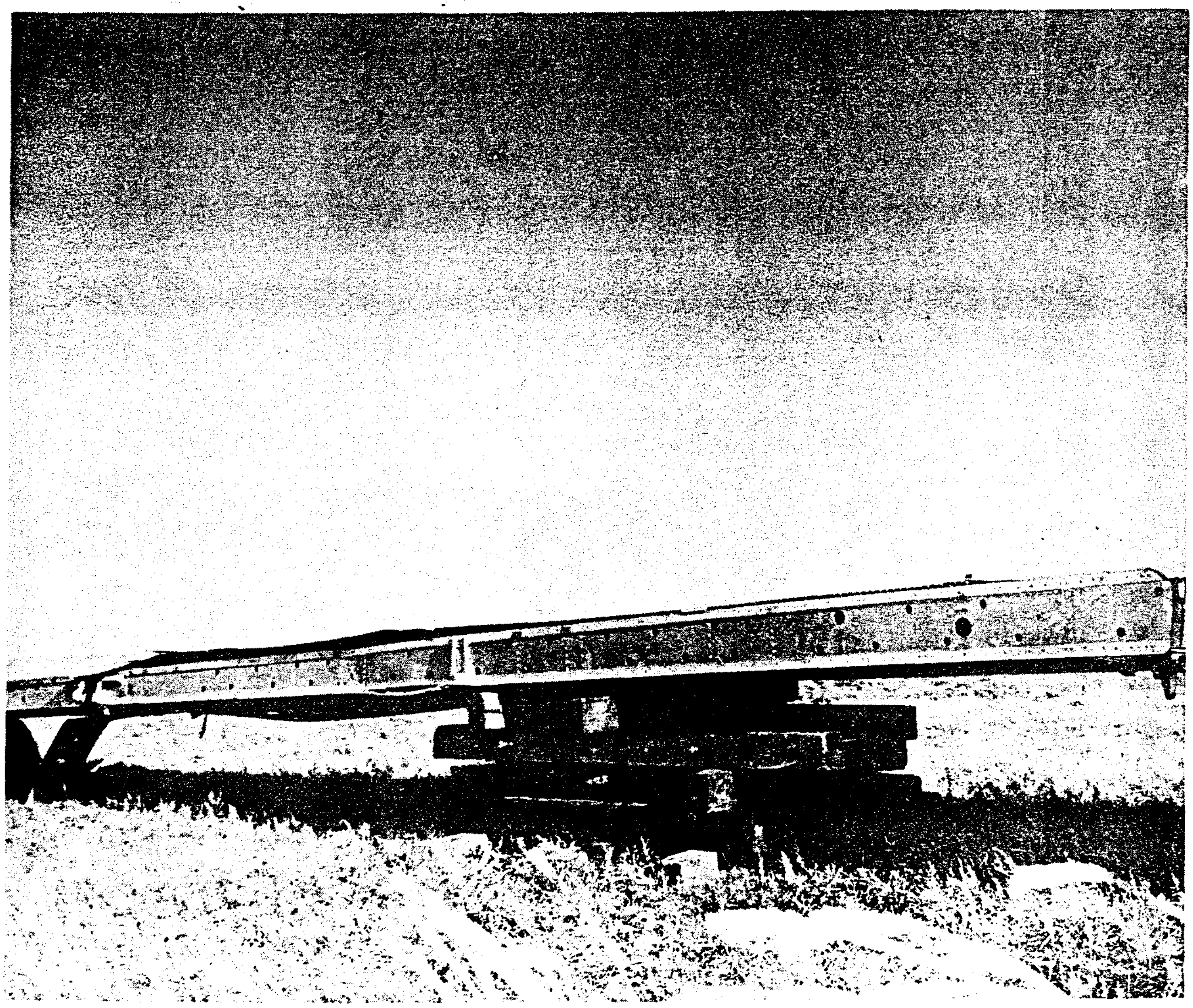


Figure 4. External View of Damage Resulting From the Detonation of a 1/2 lb. Spherical Pentolite Charge Within the Right Wing Spar Box.

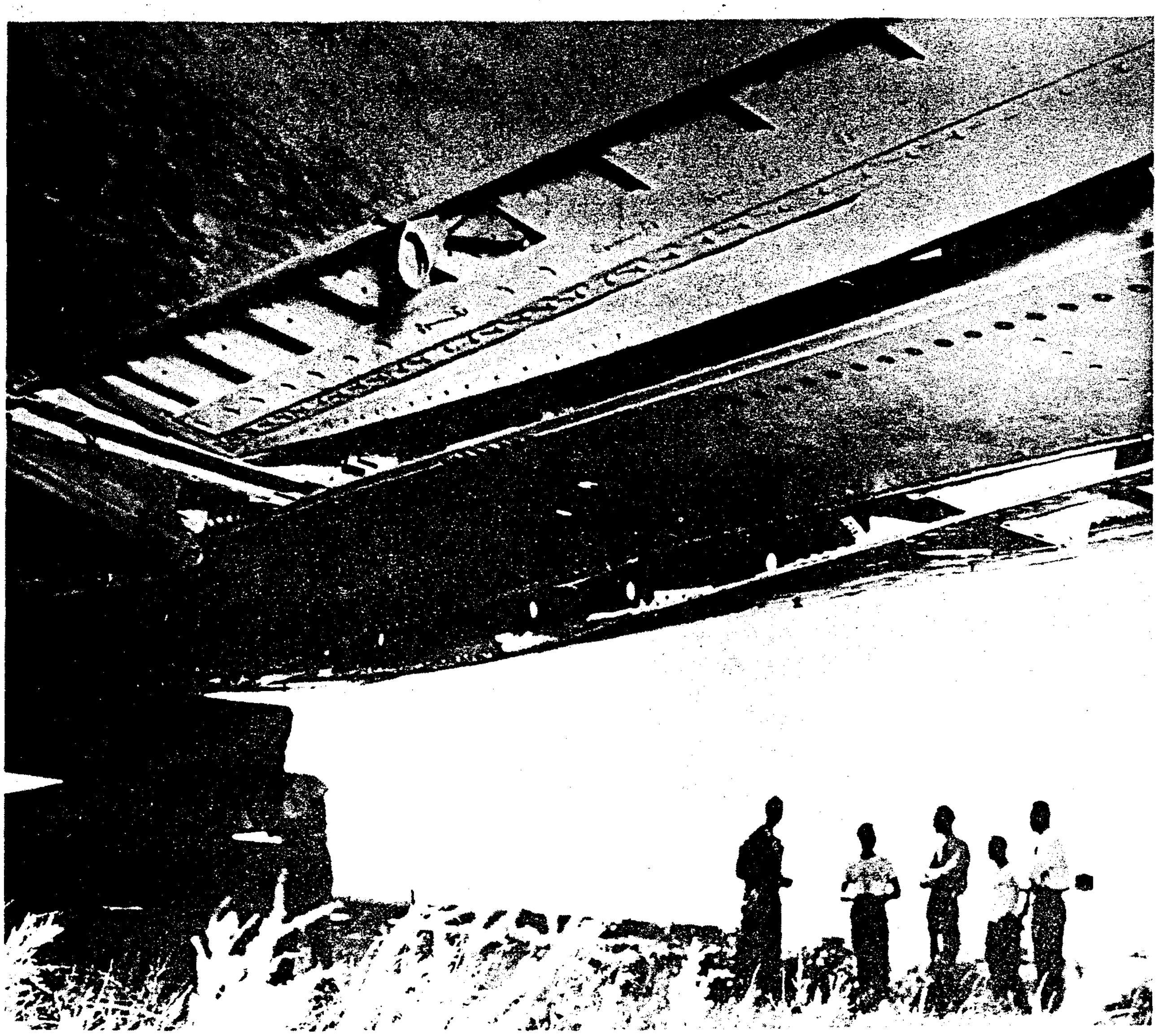


Figure 5. External View of Damage Resulting From the Detonation of a 1/2 lb. Spherical Pentolite Charge Within The Right Wing Spar Box.

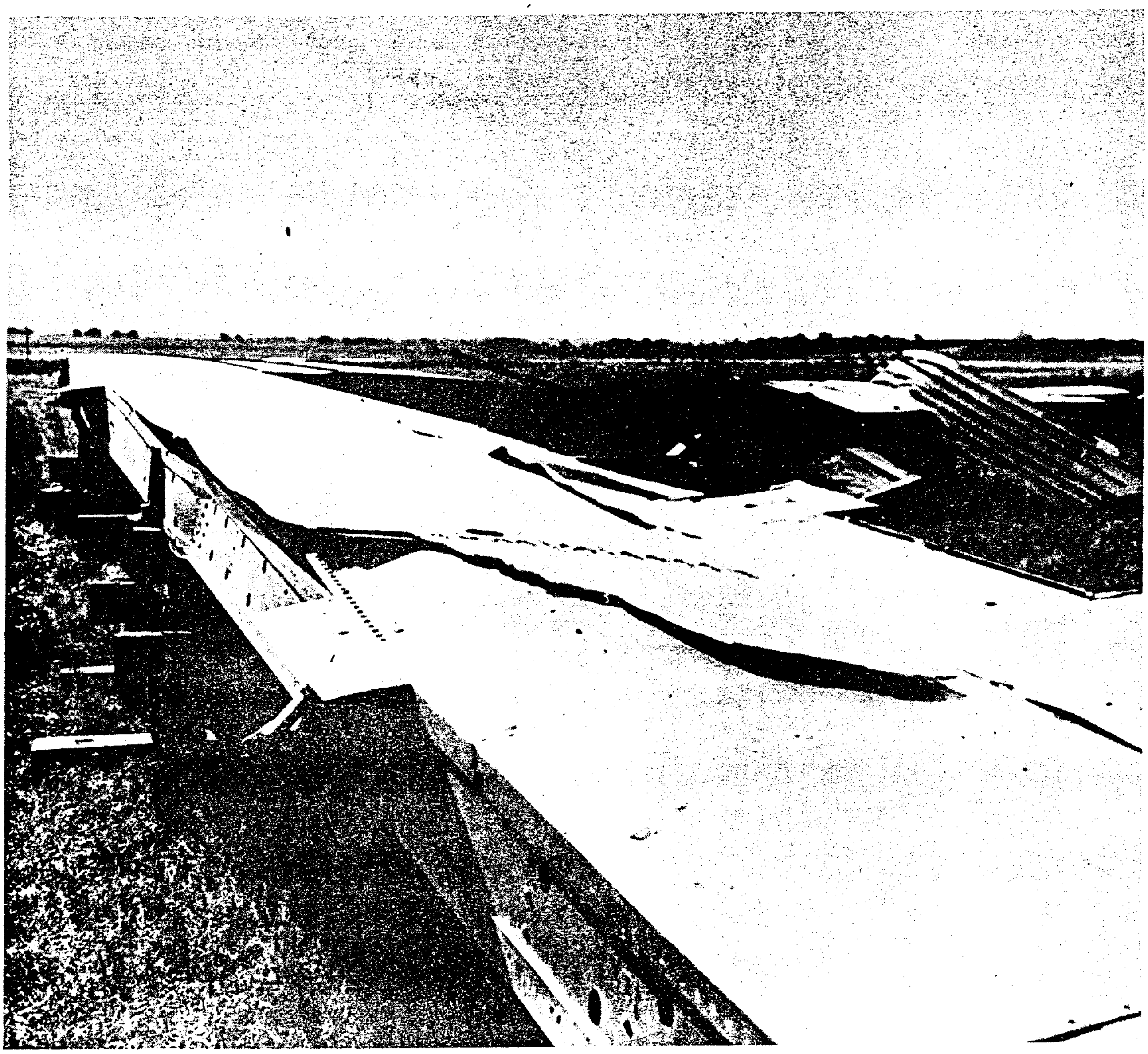


Figure 6. External View of Damage Resulting From the Detonation of a 1/2 lb. Spherical Pentolite Charge Within Right Wing Spar Box.

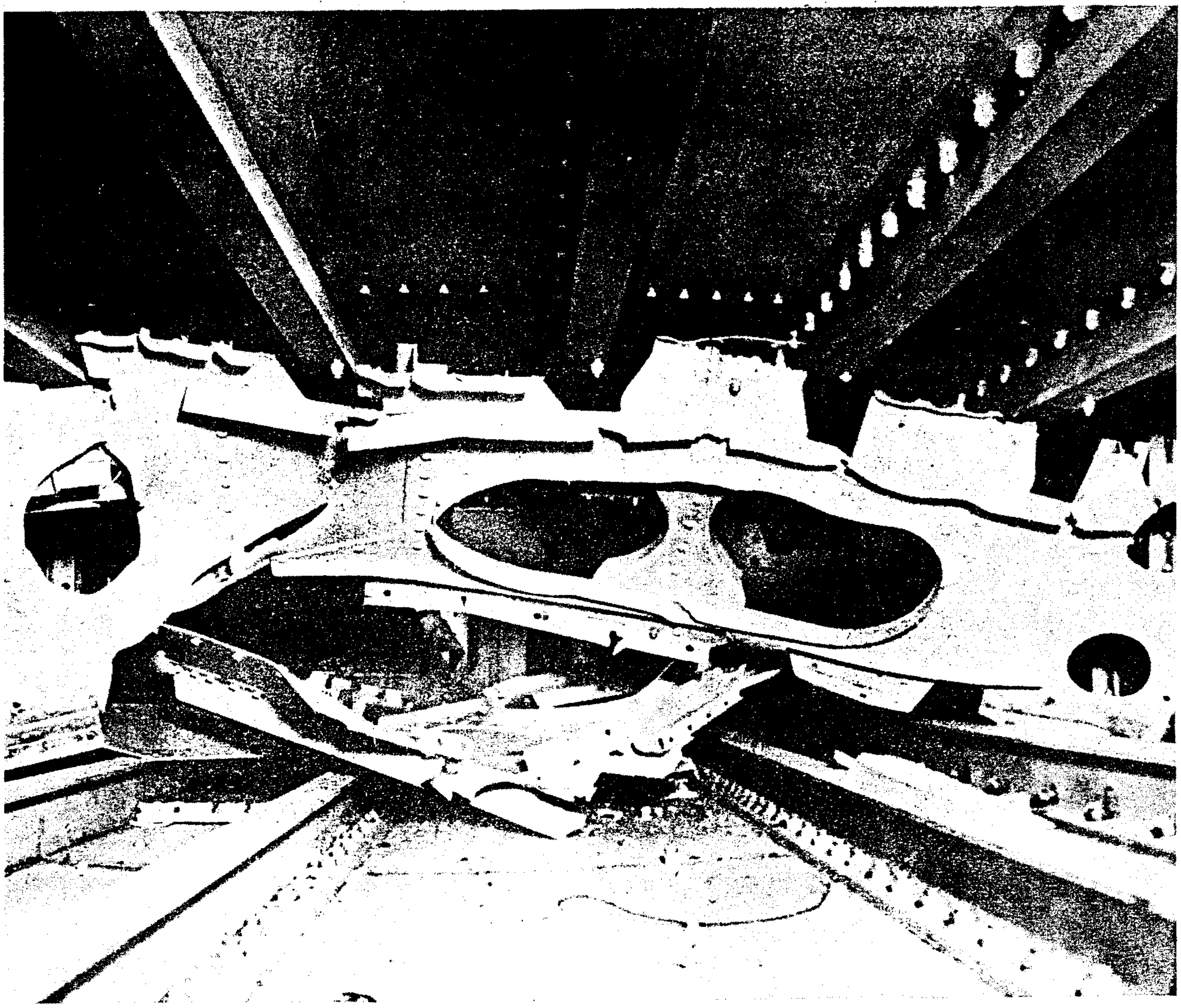


Figure 7. Internal View of Damage Resulting From a 1/2 lb. Spherical Pentolite Charge Detonated Within the Spar Box.

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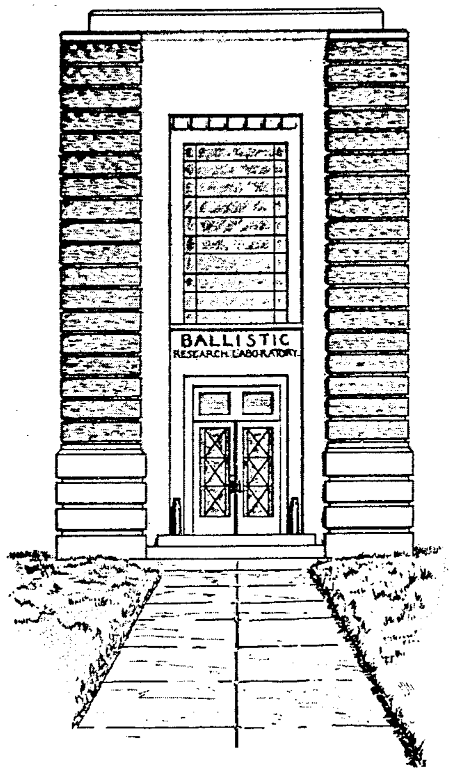

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